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THE VIGIL NETWORK SYSTEM

OBSERVATIONS ON THE ESTABLISHMENT OF BENCHMARK HYDROLOGIC STATIONS IN SMALL WATERSHEDS IN THE UNITED STATES, TOGETHER WITH SUGGESTIONS FOR THE ESTABLISHMENT OF SIMILAR SITES IN GREAT BRITAIN

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Recently there has been growing emphasis in the United States regarding the importance of establishing 'benchmark hydrologic stations' for the purpose of observing and measuring a large number of hydrologic and sedimentation parameters consecutively over a long time period. Vigil Network stations, six of which have been established during the summers of 1962 and 1963 in the states of Montana and Wyoming, are planned to extend to all the major climatic and physiographic provinces of the U.S.A. Their purpose is to obtain measurements of the many hydrologic and geomorphic variables in small drainage basins to aid in the better understanding of the hydrology of larger catchments, rates of sediment yield, and the patterns of subaerial erosion. These observations are based in part on the point of view expressed by Horton[1]) wherein, for example, measurement of rainfall intensity, infiltration capacity, surface roughness and the associated efficiency of overland flow can enable some rational approach to be made towards the understanding of such features of landscape geometry as the length of overland flow, drainage density and valley-side slope forms (See also Melton[2])). Other basin parameters to be observed include those of lithology, "topographic roughness", aspect, soil shearing resistance, etc. – all of which influence the movement of water and debris within and from the basin.

Because of the large number of drainage basins to be observed and the small number of trained observers available, installations for making these measurements must be simple, and readings in these often remote areas must be rapid so as to give maximum information in the minimum amount of time. Simplicity is the keynote, and it should be emphasised that many of the techniques described here are not intended to replace more sophisticated methods, when the latter are available. Often the importance of numerous observations from small watersheds only becomes fully apparent when their relevance to the larger drainage basin is understood. In short, there is need for the analysis of larger drainage basins in terms of their constituent parts, such that a knowledge of the total water and sediment "budgets" in the lowest order basins (see below) will lead to a more complete understanding of the "economy" of higher order basins.

The total expenditure involved in the installations described in this paper is small; twenty five pounds for each catchment is probably an over-estimate. It is proposed that the data collection from these sites should be carried out by small groups of University lecturers, research students and interested staff of river boards, such that in this respect also the present proposals will involve negligible financial outlay. The frequency of observations necessary, for example, of mass movement may be as little as twice a year. This means that a small group of four or five individuals would be able to keep consecutive records at as many as a dozen stations. It is only in the labour of installing the equipment that significant expenditure is envisaged, and the cooperation of local river boards is being sought to this end.

The first step in establishing a Vigil Network site is the careful selection of a small catchment area which meets as many of the following requirements as possible:

(a) The basin should be a first or, at the most, a second order drainage basin as defined by Strahler[3]). According to his definition a first order basin is drained by one of the smallest fingertip channels which form the recognisable basis of channel delineation in the area, and a second order basin is formed by the junction of any two first order streams. Three of the American Vigil Network sites which have been established are first order basins and the other three are second order basins.

(b) The basin should be small enough for adequate plane table mapping in about one day. This would suggest a length of main channel not greater than three thousand feet and a total area of less than half a square mile. The largest of the American sites is Last Day Gully near Hudson, Wyoming[4]), which has a channel length of three thousand five hundred feet and a total basin area of one fifth of a square mile.

(c) The lithology should be as nearly homogeneous as possible. However, Forsaken Gully near Moneta, Wyoming consists of a rapidly alternating sequence of unconsolidated Tertiary sandstones and claystones, horizontally bedded.

(d) Remoteness from settlements is an advantage, as installations can easily be disturbed.

(e) The basin should be topographically clearly-defined. Those having a high hyposometric integral[3]) will obviously give the most readily observable processes and morphometric changes, and these should form the basis of an initial network.

When these criteria have been considered and a basin chosen, it has been the rule to proceed with the drawing of a plane table map of the whole drainage basin at a scale of one inch to one hundred feet. Last summer this laborious procedure was supplemented in the United States by aerial surveys and in the future many of the maps will be drawn from air photographs.

After a detailed map has been prepared, a series of cross-sections across the stream channel are surveyed, and monumented at each end in such a way that they can be identified and resurveyed at a later date. The cross-section serves its primary usefulness in the measurement of aggradation or degradation of the channel bed through time.

The following method gives a more direct approximation of the net amount of channel scour and fill between observations. On a monumented cross-section, holes are dug in the stream channel twice as deep as the estimated maximum scour. In the south-western states of America, four to five feet is the normal depth but in the eastern states (as presumably in Britain) one to three feet is probably enough. A length of chain is held vertically until the hole is refilled. If the stream bed is scoured a part of the chain is exposed and laid horizontally on the stream bed by the current. It is then covered up in that position when fill occurs after the initial scour. On the resurvey, a hole is dug until the chain is reached and the position on the chain where it changes from a vertical to a horizontal position is measured. It is worth pointing out that although this technique has been used most successfully in ephemeral stream channels, it is also a powerful tool in more humid environments with perennial streams and should therefore be used in this country to give scour and fill measurements, data on which are non-existent at present. The chains record only the maximum depth of scour at each spot but it is assumed that this maximum is associated with the maximum flood waters – perhaps measured by a "crest-stage gauge".

The "crest-stage gauge" is a simple instrument devised to measure maximum depth of water in a stream channel between times of surveying its drainage basin[5]). Although more sophisticated stream gauges are preferable, the crest-stage gauge is simple, cheap and effective for estimating flood discharges during which much of the channel scour occurs. This measurement is conducted in conjunction with rainfall recordings from at least one rain gauge situated within or near the basin.

The movement of individual marked or painted rocks in the stream bed, in conjunction with recordings from the crest-stage gauge, enables estimates to be made of the ability of specific flows to move various sizes of bed material.

An even more simple technique is used in determining rock movement in small headwater rills. In each individual rill rocks of a uniform size are painted and located at ten foot intervals along the rill channel thalweg, each being numbered in a different colour representing the initial distance in feet upstream from the base point. Adjacent rills have been chosen in the Santa Fe area of New Mexico to study the effects of different factors involved but so far only rocks of three to four inches diameter have been used.

To measure surface erosion in the United States, iron nails, eight to ten inches long, are slipped through a large washer and driven into the ground in a vertical position until the washer is flush with the ground surface. Surface erosion undermines the washer which then slips down the nail, making measurement direct and simple. In Britain, where creep is usually a more important slope process than surface sheetwash, (although this has been measured in Scotland by surface pans[6]), more exact methods of measuring creep have been devised by the use of "Young Pits"[7] and spirit level bars[6]. These types of creep observations should form an especially valuable part of any British Vigil Network.

Measurements of vegetation foliage and root densities (dry weights per unit area of surface or per unit volume of soil) may be of great importance in analysing the water budget and resistance to debris movement within the basin. This may be done by a quadrat or transect method, the quadrats being chosen so as to include a representative number of plant associations within the drainage basin or the transect chosen so as to pass over as many associations as possible. Random sampling is then carried out within the quadrat or along the transect. The important information to be gained from this work is not the geographical distribution of particular species or genera, useful as this might be in a study of plant ecology, but that relating to the total surface and subsurface *mass* of vegetation.

A similar method of sampling could be adopted with regard to the collection of soil samples on representative slopes and lithologies within the drainage basin. The work of Chorley[8] on some Oxford soils has shown that simple measurements can provide some rough index of surface resistance to erosional processes. Soil samples should also be analysed to give size distributions and clay composition, such that shearing, permeability, frost-heaving, and other characteristics may be inferred, as well as field density and moisture conditions. More simple field shearing tests are described by Melton[2] and by Krumbein[9].

In the absence of the conventional measures of soil permeability, some simple techniques such as have been described by Schumm[10] and Melton[2] might be employed in this country, and others developed.

In order that there may be a record of changes in the hydrology of a small drainage basin it is essential to know its geometry and for this reason it is most important that the work of surveying and the levelling of detailed cross-sections be carried out first. The burying of chains and the installation of erosion pins for observation of surface erosion are probably the least important of the above suggestions as far as a British Vigil Network system is concerned, but the suggestions for measurements of flood run-off, debris movement by streams, mass movement, and vegetation and soil characteristics are regarded as a basic *minimum* for each site.

It is proposed that at least 20 Vigil Network sites be established within the major administrative catchment areas of Great Britain, in as widely varied lithological, climatic, vegetative and topographic conditions as possible, giving enough sample readings to be handled by computer techniques. It is vital that the selection and establishment of sites, data collecting, analysis and publication of results should be coordinated in some manner with similar results which are being obtained in the United States [11]. It would be most valuable if anyone who has an interest in the establishment of such a Vigil Network programme would contact the authors of this newsletter, who are already in the process of establishing sites in Bedfordshire, Norfolk, Montgomeryshire and Wester Ross.

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